Designing an AIS-based communicationinfrastructure to enhance security and navigation in seafaring as an example of solving real world problems in an IT-project

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Abstract: This paper deals with the design of a maritime and land-based communicationinfrastructure and its associated technologies. In seafaring it is not possible to track precise and fine-grained real-time weather data while on water. The refresh period of weather data and the coverage of the already existing weather stations on seas are insufficient. In addition, for non-commercial seafaring vessels, there is little or no reliable information on depth for many regions. These issues can compromise security and safety in open waters.

In this paper, the very high frequency (VHF) based AIS-technology will be described shortly. Based on this the concepts of our newly developed infrastructure will be introduced as an example of how real world problems are going to be solved in an IT-Project. The new infrastructure allows us to determine correct depth and real-time weather data, and to send these data to a land server for further processing. This is possible through the links between an on-board server and the land-based server.

1. Introduction

There are various electronic devices aboard a ship that support navigation and security. At the same time, the number of different internet platforms is increasing. Mobility of devices, the worldwide access to the internet and many advanced server systems bring the capabilities for communicating and transporting data between vessels and land-based stations.
A few companies identified these issues and developed internet-platforms to receive specific weather data for seafaring. However, to observe these data in real-time and without any internet connection is not possible. The company Oceansweather [1], which was founded 1977, offers an internet service for observing the worldwide maritime weather situation. The National Oceanic And Atmospheric Administration (NOAA) developed an additional web application [2] that lets the user analyze the weather situation in greater USA and its coastal areas. Finally, the company SVB GmbH [3] from Bremen developed the online platform Portmaps [4]. Hence, the user is able to check the worldwide weather on seas through a Google Maps layer.

Latest weather information is essential in seafaring and has to be observed constantly. The weather situation in open waters can change immediately and lives are threatened in the worst-case scenario. Accurate, reliable and current information about the weather on the course of a ship has to be accessible for seamen. Specific weather stations are installed on buoys that send

the latest weather data of their region to a server on land. The buoys coverage on sea is coarse grained; therefore the collected weather data is not precise enough.
Also, existing online services deliver non real-time weather data. Therefore it is only possible for a skipper to check the weather before going out to sea. Moreover it is not possible to observe real-time weather data while in open waters. Finally, there exist no devices or chart plotters that are able to visualize the weather data.
The depth data is another significant factor for the security in seafaring. This information is measured by the so-called water departments. A waterway is an area on a river or near coasts where commercial vessels can pass through because of the adequate depth of water. The depth of the waterways is measured by the water departments regularly. The boundary areas of the waterways are designated for non-commercial vessels, whereby the depth of these areas is not measured often and fine-grained by the water departments. As a further consequence non-commercial vessels may not have any depth information in a specific region on sea.
The low refresh-period of the depth data and the issue of missing information in relevant boundary areas reduce the security in seafaring.

2. AIS-Technology

The Automatic Identification System (AIS) is a widespread information system that should enhance the security and efficiency in seafaring through its extended information transfer [5]. It is a requirement for commercial vessels since 2004 [6]. The AIS is based on the very high frequency (VHF) maritime radio. The primary function of this technology is to improve navigation in open waters, avoid possible collisions of vessels and enhance the data and information transfer between vessels and AIS-capable objects.
A vessel endowed with AIS sends continuous information through an AIS-transmitter about its own situation via the VHF maritime radio. This information includes for instance the current position, speed, navigation status, weather data or the name of the sending vessel. Other AIS-capable objects that are close to the AIS-transmitter in a radius of 60 nautical miles can receive the transmitted data record [7]. Depending on the used Hard- and Software on board of the receiving ship, the received data can be monitored for example in a notebook. Therefore extended Information can be exchanged between ships, buoys and other AIS-capable objects like land-based AIS-stations.
It is important to mention that this technology cannot replace the well-known Radar system [8] because AIS is only able to detect transmitting and active AIS-objects. However, the Radar system identifies inactive objects on seas like rocks or coastal regions [8].

3. The Approach to develop the communicationinfrastructure

The insufficient quality of the obtained weather and depth data and the consequent low security in seafaring was the key factor to create a communicationinfrastructure that enhances the security and navigation. Therefore in this IT-project we created a solution of a real-world problem.
To identify the needs in this domain, the functional and technical requirements needed to be defined in the first phase of the project. Having a course-grained overview of the requirements, a functional specification document was created that defines concrete requirements to the system and gives legal security to the developers of what needs to be implemented for the client. Based on the requirements we designed the technical aspects of the communicationinfrastructure that needed to be implemented. Figure 1 illustrates the designed infrastructure and the participating ships and stations in an UML diagram.
We came up with the solution of developing two components that result as the major components of the infrastructure. An on-board unit, installed and operating on a vessel, collects weather and depth data from sensors installed on the ship. The data is transported via the NMEA-protocol [9], so the board-server can receive the data through an NMEA-interface.

Once the on-board unit receives the weather data, it forwards the information via Ethernet to the AIS-Transmitter. Thereafter, the transmitter sends the collected and current weather information of the ships region to surrounding AIS-capable objects. Already existing AIS-land-based stations, which are based at coasts, belong to the AIS-capable objects and can also receive the transmitted data from seas. The receiving objects can then monitor the weather conditions of the

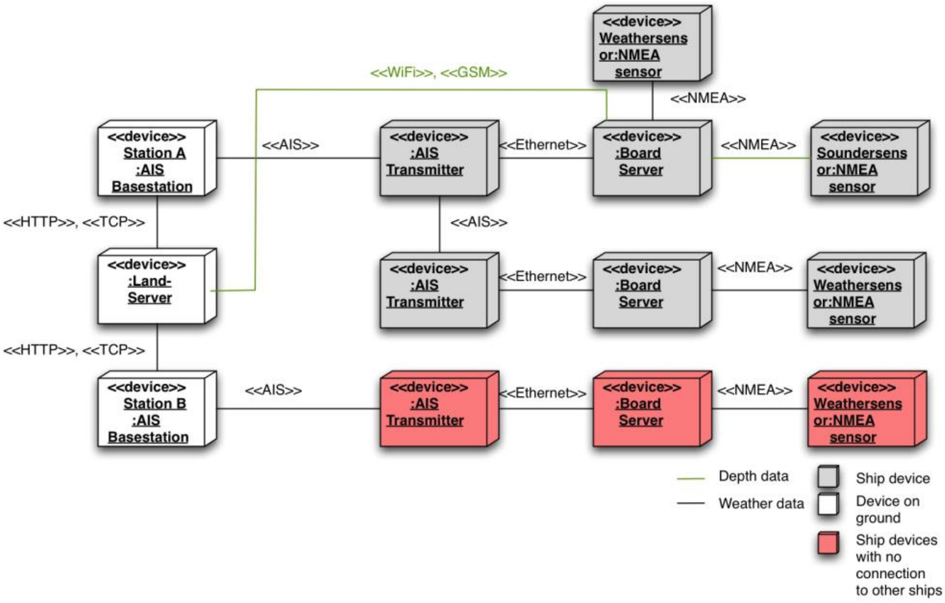

Figure 1: The designed communicationinfrastructure

sending vessel on a mobile device or laptop in real-time. If vessels are not in the surrounding of the sending object and are therefore unable to receive the data, there is another way of receiving this information through the second important component, the land-based server. This server receives the transmitted data from an AIS-land-based-station via HTTP and TCP-protocol. The AIS-land-based-station is located in the same region as the sending ship and received the weather data via AIS. Furthermore the land-based server forwards the weather data to another AIS-land-based-station that is in the same region as the vessel, which cannot receive data from other AIS-objects. The AIS-land-based-station sends the data finally to the distant AIS-object. In figure 1 the red colored components represent a vessel with no direct AIS-connection to other AIS-objects. In this manner the distant vessel is able to monitor real-time weather conditions of ships that are based in other geographical regions.

Regarding the depth data, the on-board server saves the measured data during a ship journey until it can connect via Wi-Fi or GSM to the land-based server. Once the connection is established, the depth information and the corresponding GPS-data are sent to the land-based sever, which archives the measured data. The GPS-data is measured through a specific GPS-sensor installed on the vessel. The green colored connections in figure 1 visualize the transportation path of the depth information.

In addition, a web interface mediates the access to weather and depth information through a web-connection to the land-based server. Thus users can use mobile devices or any other internet-capable computer to check weather and depth conditions in specific regions.

For the whole project-life-cycle including the implementation, we realized that agile project methods [10] i.e. scrum [11] need to be applied. In this way, additional changes of the requirements can be applied easier, work processes are more flexible and the team-members are able to learn new aspects of project management from the current project.

4. Results and Conclusion

The existing and established technologies to measure weather and depth data are not sufficient to provide high security in seafaring. Weather data can be gained via specific internet platforms, however real-time weather conditions cannot be monitored offline. Also, there is little or no reliable information on depth for many regions on seas.

Therefore we decided to expand a concept to enhance the security and navigation in open waters. We presented our designed communicationinfrastructure, which is based on the AIS-technology and is composed of an on-board unit and a land-based server system. Through the resulting collaboration of the vessels and the AIS data transfer, real-time weather data can be observed. Through the collaboration with already existing AIS-land-based stations, the land-based server system makes it possible to reach vessels in different geographical locations. Moreover every vessel operates as a weather station. As a consequence of this, the number of weather stations increased through the additional AIS-capable vessels. The interaction between the on-board unit and the land-based server provides a more fine-grained coverage of depth data for non-commercial vessels. The depth data can be accessed though a web service. Hence our infrastructure provides an improvement of security and navigation on seas.

As an example of how real world problems are going to be solved in IT-projects, our newly designed communicationinfrastructure shows that the process of defining requirements has to be done in the first phase of the project. The resulting functional specification document is the fundament for designing the technical components of the new system. In addition, the entire project should be managed with agile project management methods, because of its flexibility and adaptability.
Implementing and testing the on-board unit and the land-based server system is the current task of our research team.

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